1   TO WHOM IT MAY CONCERN:

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3   BE IT KNOWN THAT I, ROSS BROWN, a citizen of

4   the United States of America, residing in Murrieta,

5   in the County of Riverside, State of California, have

6   invented a new and useful improvement in

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9   **AIR CYCLE PRE-COOLING SYSTEM**

10   **FOR AIR SEPARATION UNIT**

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BACKGROUND OF THE INVENTION

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3   This invention relates generally to

4 processing of a stream of air prior to its separation

5 into components, and more particularly concerns

6 efficient drying and cooling of such air stream.

7   Air separation units (ASU) separate air into

8 its constituent parts, nitrogen, oxygen and Argon.

9 This is performed by distillation at low temperatures

10 (-300DegF). Preliminary to cooling the air feed stock

11 to the liquefaction point, it is necessary to remove

12 the minor amounts of water and carbon dioxide present

13 in air, prior to the introduction of air to the heat

14 exchangers where the air is exposed to freezing

15 temperatures. In modern plants this is done by a two

16 step process. First the compressed air is cooled to

17 about 5DegC(41DegF), where most of the water is removed

18 by condensation and separation. Next the cooled air is

19 passed through absorbent beds containing a suitable

20 absorbent such as a molecular sieve, where the last

21 traces of moisture and the carbon dioxide are removed.

22 The reduced air temperature is necessary to provide the

23 absorbent function with a high degree of affinity for

24 carbon dioxide. The beds are regenerated periodically

25 by either de-pressurization (Pressure Swing Absorption)

1 or more commonly heating (Temperature Swing

2 Absorption).

3   There is need for improvements in such

4 processes, which typically employ mechanical

5 refrigerators running with either Freon or ammonia.

6 The evaporator operates at temperature close to

7 freezing to prevent the water in the compressed air

8 from freezing on the tube surfaces. The heat absorbed

9 in cooling the air and condensing the water combined

10 with the power used in the compressor is rejected to

11 either air (ambient) or a cooling water circuit.

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13   **SUMMARY OF THE INVENTION**

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15   Basically, the invention provides a method of

16 processing air prior to separation of such air into

17 gaseous components and includes the steps:

18   a)   first compressing a stream of air and

19 cooling the compressed air, to enable water separation

20 and removal from the stream, to provide a dry stream of

21 air,

22   b)   then further compressing the dry air

23 stream and cooling the compressed dry air stream to

24 enable removal of contained remanent water,

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1   c)   then expanding the cooled air stream in

2   an expansion stage which extracts work from the

3   expanding stream,

4   d)   then passing the expanded air stream to

5   a separator operating to remove water from the stream,

6   thereby producing dry air passed to an air component

7   separation stage or stages.

8   The air cycle refrigeration process described

9   herein, employs reverse Brayton cycle technology to

10   replace the mechanical refrigerator and evaporator.

11   While thermodynamically less efficient than the Rankine

12   cycle equipment it replaces, it has the advantage of

13   simplicity and the avoidance of employing

14   chlorine/fluorine compounds which are potential

15   damaging to the atmosphere.

16   These and other objects and advantages of the

17   invention, as well as the details of an illustrative

18   embodiment, will be more fully understood from the

19   following specification and drawings, in which:

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21   **DRAWING DESCRIPTION**

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23   Fig. 1 is a flow diagram showing an air

24   processing system employing the invention; and

25   Fig. 2 shows a similar system.

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1   **DETAILED DESCRIPTION**

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3   In Fig. 1, supply air 1 is first compressed

4   in a compressor 2, driven by a prime mover 3, to a

5   higher pressure p_1 at 4 (normally to between 5 and 15

6   atm). The compressed air is then cooled in an after

7   cooler 5, to a temperature t_1 using either ambient air

8   or cooling water as the cooling medium to which heat is

9   transferred. Cooled air is passed at 6 to separator 7.

10   Water in excess of the dew point (condensed water) in

11   the cooled compressed air is separated in separator 7

12   and removed at 8. The dry compressed air at 9 then

13   enters a booster compressor 10 (normally a centrifugal

14   compressor) where the pressure is increased to p_2.

15   Exit air at 11 is cooled to temperature t_2 at cooler

16   12, and resulting wet air flows at 13 to a separator 14

17   where additional liquid water is separated and drained

18   15. The cooled boosted air provided at 16 is then

19   expanded in an expansion device 17 (normally a turbine)

20   where the extracted work cools the stream to

21   temperature t_3 as the pressure is reduced to p_3. The

22   work extracted as shaft power is used to power the

23   booster compressor through a shaft 18.

24   The cooled wet air flows at 19 to a final

25   separator 20 that removes the liquid water 21 produced

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1   in this final cooling. The cold dry air 22 flows to

2   the air separation unit 23 and is separated into its

3   constituent parts, oxygen, nitrogen and Argon. The

4   product streams 24 are transported for use.

5   The final pressure p_3 is less than the

6   discharge pressure p_2 of the air compressor. The

7   difference in the air pressures and the resultant work

8   that is required to get it there, represents the power

9   penalty for producing the refrigeration.

10   Since it is necessary to maintain the turbine

11   exhaust temperature at approximately 5DegC to prevent

12   solid ice from forming in the exhaust, the inlet

13   temperature to the turbine is controlled by bypassing

14   the booster aftercooler 12. An air flow bypass line 25

15   and control valve 26 are provided for this purpose.

16   The total flow through the system is controlled by

17   adjusting the positions of the inlet nozzles on the

18   turbine. See adjustment device 26.

19   In the similar Fig. 2 system, elements the

20   same as in Fig. 1 bear the same identifying numbers.

21   Representative physical conditions are shown.

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